ENERGY ENGINEERING ANALYSIS
BUILDING 2

WALTER REED ARMY MEDICAL CENTER
WASHINGTON, D.C.

CONTRACT NO. DACA65-82-C-0084

EXECUTIVE SUMMARY
INCREMENTS A, B, F, G

FINAL SUBMITTAL

PREPARED FOR

DEPARTMENT OF THE ARMY

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LIST OF ABBREVIATIONS

AFEP	-	Army Facilities Energy Plan
AHU	-	Air Handling Unit
AI	-	Analog Input
ANSI	-	American National Standards Institute
AØ	-	Analog Output
ASHRAE	-	American Society of Heating, Refrigeration and Air Conditioning Engineers
ATC	-	Automatic Temperature Control
BTU	-	British Thermal Unit
BTUH	-	BTU Per Hour
CFM	-	Cubic Feet Per Minute
CPA	-	Control Point Adjust
CPU	-	Central Processing Unit
°F	-	Degree Fahrenheit
DI	-	Digital Input
DØ	-	Digital Output
ECIP	-	Energy Conservation Investment Program
ECM	-	Energy Conservation Measure
ECU	-	Energy Conservation Unit
EEAP	-	Energy Engineering Analysis Program
EMCS	-	Energy Monitoring and Control System
ETL	-	Engineer Technical Letter
FID	-	Field Interface Device
HVAC	-	Heating, Ventilating and Air Conditioning
IES	-	Illuminating Engineering Society
KBTU	-	Thousand BTUs
KLB	-	Thousand Pounds (of steam)
KW	-	Kilowatt
KWH	-	Kilowatthour
MACOMs	-	Major Army Commands
MBTU	-	Million BTUs
MILCON	-	Military Construction
MUX	-	Multiplexing Panel
O.A.	-	Outdoor Air
PDB	-	Project Development Brochure
PEPCO	-	Potomac Electric Power Company
VAV	-	Variable Air Volume
WG	-	Water Gauge
WRAMC	-	Walter Reed Army Medical Center

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I. INTRODUCTION

1.1 SCOPE OF TASK

In May, 1982, H. F. Lenz Co. was awarded a contract (DACA65-82-C-0084) to conduct an Energy Engineering Analysis Program (EEAP) for Building 2, Main Hospital, Walter Reed Army Medical Center, Washington D.C. The scope of the program is to develop a systematic plan for projects that will be implemented to reduce energy consumption in compliance with the objectives set forth in the Army Facilities Energy Plan (AFEP).

The evaluation is to consider all practical methods of energy conservation and incorporate applicable data and results of related studies where feasible. Project Development Brochures (PDBs), DD Forms 1391 and supporting documentation are required for feasible energy conservation projects.

1.2 APPROACH

Building 2, Main Hospital, Walter Reed Army Medical Center is a seven floor structure with an interfloor between floors and between the Seventh Floor and the roof. There is grade access at both the First and Second Floors. The First Floor is below grade on two sides. The elevations exactly face the compass directions.

The building is very compact, with four equal sides, the greatest dimension being 486 feet on the uppermost floors. The average floor to floor height is 18 feet including a 9 foot interfloor. Total area for the basement, penthouses and floors One through Seven is 1,259,281 square feet.

Total area for the seven interfloors is 1,221,662 square feet. Floors One through Three contain administrative and support spaces. Floors Four through Seven are patient floors. The plan is compact (i.e. square) with corridors which implement loop circulation schemes. Floors Five through Seven have interior courtyards.

The main HVAC system for Building 2 consists of Trane Climate Changer dual duct supply air units serving a network of Tuttle & Bailey dual duct mixing boxes. In general, surgical areas, intensive care areas and the ward areas of the patient floors are served by 100% outdoor air systems. The core section of the patient floors, outpatient clinics and administrative areas are served by combination supply/return systems.

Field survey effort for the EEAP concentrated on HVAC, control and electrical systems in the basement, interfloors two through five and the penthouses. In addition, lighting systems for floors one through five and the interfloors were evaluated. In order to establish completeness of the field survey effort, it should be pointed out that, per pre-negotiation discussions, floors five, six and seven were to be considered typical with a survey required for only one of the typical floors.

In that there are numerous typical systems involved in Building 2, the analysis of potential retrofit projects was initially developed in terms of a typical unit. Where the results of this initial analysis demonstrated both technical and financial feasibility, details were refined to extend the project to all applicable units/systems in Building 2 and appropriate support documentation was developed.

II. ENERGY CONSUMPTION

2.1 BASE YEAR

In general, the hospital was not fully occupied until the end of FY'78. With that in mind FY'79, rather than FY'75, must be used as the base year for measuring the progress of energy conservation activities. Base year consumption history for Building 2 is as follows:

FY'79	ELECTRICITY	67,111,890	KWH
		778,498	MBTU
		563,540	BTU/SQ FT/YR
	#6 FUEL OIL	1,717,168	GAL
		250,707	MBTU
		181,482	BTU/SQ FT/YR
	TOTAL ENERGY	1,029,205	MBTU
		745,022	BTU/SQ FT/YR

2.2 LATEST FISCAL YEAR

Consumption history for the most recent fiscal year is as follows:

FY'82	ELECTRICITY	64,080,100 KWH
		$ 3,278,979.00
		743,329 MBTU
		538,082 BTU/SQ FT/YR
	#6 FUEL OIL	1,898,083 GAL
		$ 1,727,256.00
		277,120 MBTU
		200,602 BTU/SQ FT/YR
	TOTAL ENERGY	$ 5,006,235.00
		1,020,449 MBTU
		738,684 BTU/SQ FT/YR

A comparison of source energy consumption for FY'79 and FY'82 is as follows:

	ELECTRICAL	#6 FUEL OIL	TOTAL
FY'79	778,498 MBTU	250,707 MBTU	1,029,205 MBTU
FY'82	743,329 MBTU	277,120 MBTU	1,020,449 MBTU

III. ENERGY CONSERVATION MEASURES

3.1 POTENTIAL ECMs INVESTIGATED

The following potential energy conservation measures (ECMs) were investigated. Measures with an NA designation after the description were determined to be inappropriate for Building 2. Measures with an NCE designation were rejected because they were not cost effective. Measures with no additional information following the description have been developed as ECIP projects.

3.1.1. Architectural ECMs

1. Reduction of glass area - NCE
2. Solar films - NA
3. Double glazing - NA
4. Additional insulation for the interfloor areas - NA
5. Insulated panels - NCE
6. Weatherstripping and caulking - NA
7. Additional vestibules - NA
8. Load dock seals - NA

3.1.2 Mechanical ECMs

1. Reduce supply air quantities
2. Balance air and water systems
3. Add return air connection to 100% outdoor air supply air units -NCE

4. Convert constant volume air handling systems to variable air volume (VAV) - NCE
5. Prevent lobby air stratification - NA
6. Insulate steam lines - NA
7. Add infrared heaters - NCE

3.1.3 Electrical ECMs

1. Reduce lighting levels via delamping
2. Replace incandescent lighting on interfloors
3. Photocell dimming of fluorescent lights
4. Revised switching of corridor lights - NCE
5. Replace kitchen light fixtures - NA
6. More efficient lighting source - NA
7. High efficiency motor replacement - NA
8. Power factor improvement - NA

3.1.4 Automatic Control ECMs

1. Night setback/setup
2. Improved economizer cycles
3. Control hot water circulating pumps
4. Seasonal reset of thermostats
5. Install time clocks - NA
6. FM radio controls - NA
7. Radiator controls - NA

3.1.5 Plumbing ECMs

1. Shower flow restrictors
2. Hot water heater shutdown or controls modification - NA
3. Decentralize domestic hot water heaters - NA
4. Install reduced flow flush valves - NCE
5. Replace city water cooled systems - NCE

3.2 ECIP PROJECTS DEVELOPED

The ECIP projects in the following three sections have been developed in order to reduce Building 2 annual energy consumption in compliance with the objectives set forth in the AFEP. In each case, a brief description of project scope is provided.

3.2.1 AIRFLOW REDUCTION AND AIR SIDE REBALANCING

Environmental conditions at WRAMC Building No. 2 are maintained by an air distribution system which circulates either cooled or warmed air through the conditioned space. Based on field survey data and computer load simulation, most systems are delivering air in excess of that required by both code and load requirements.

The scope of this retrofit is to reduce the air delivery rate of the air handling system fans by replacing the fans' sheaves and drive belts. Rebalancing of the air systems will be accomplished by adjusting existing volume control dampers in the air distribution systems. New airflow rates will be established from a computer program which simulates load conditions with the minimum airflow rate set by Hospital code requirements.

Calculations indicate that a 21% reduction in the airflow presently being delivered to the occupied space is possible.

3.2.2 ENERGY MONITORING AND CONTROL SYSTEM

The existing Building 2 Computerized Building Automation System, which is typical for equipment of its vintage, provides time clock scheduling and generates and displays simplistic information such as motor status, temperature, alarms, etc. It also provides centralized manual control point adjust. The control console is located in the second floor ECU room. Forty-nine field cabinets located throughout the building utilize solid-state multiplexing and decoding equipment to transmit data from field sensors to the CPU and to transmit commands from the CPU to the appropriate field equipment.

A new EMCS is being designed for the buildings of WRAMC, Main Section, not served by the existing system in Building 2, plus selected buildings at Forest Glen Annex. The scope of this project is to transfer the current Building Automation Center functions over to the new EMCS, plus add the required field hardware and appropriate software to support new energy management projects identified as part of the Building 2 EEAP.

3.2.3 LIGHTING SYSTEM MODIFICATIONS

Present lighting in the basement and on the interfloors consists primarily of incandescent fixtures. The existing fluorescent fixtures in the bridge corridors of the patient floors (five, six and seven) are left on during the daylight hours, although natural lighting is provided by the courtyard windows.

The scope of this retrofit is to replace the existing incandescent fixtures in the basement and on the interfloors with new single tube fluorescent fixtures and install automatic photocell dimming control that would provide for dimming of the bridge corridor fixtures during the daylight hours when natural lighting is provided by the courtyard windows. There are four intersecting bridge corridor arrangements on each of the patient floors that are involved in the dimming control scheme.

3.3 MINOR O & M PROJECTS

As discussed in the following section, the coils that were accessible for inspection in the air handling units are generally dirty and need to be cleaned.

3.4 REQUIRED POLICY CHANGES

During the course of the detailed field survey, conditions were encountered which suggest the need for policy changes in the areas of air handling unit filter change and coil cleaning procedures. The following recommendations summarize the situation.

1. Require that filter change log sheets be maintained at the various air handling units for ease of verification of filter change intervals.

2. Institute a procedure that requires removal of dirty filter media from Building 2 interfloor areas on a daily basis corresponding to the number of units serviced that particular day.

3. Initiate a program to spot check units which were scheduled for filter change during a given month to verify that the proper level of attention has been paid to the filter change process.

4. Verify that the dimensions of the 95% final filters being supplied as replacement units are compatible with the original space provided.

5. Initiate a program to clean all preheat coils and runaround heat transfer coils on an annual basis.

6. Whenever routine maintenance problems are encountered on an air handling unit which require the addition of access panels, consideration should be given to adding access panels of sufficient size to allow the coils associated with the hot deck and cold deck to be added to the scheduled cleaning program.

In addition, the following recommendations are made with the intent of promoting the long-term success of the recommended retrofit projects. In each case, a re-evaluation of the existing situation is warranted:

1. Increase the number of HVAC service technicians.

2. Institute procedures that provide for a detailed inspection of all air handling systems on a routine basis. It is recognized that this recommendation is somewhat dependent on the outcome of the first item.

3. Place the contractor selected to implement the rebalancing ECM under the supervision of the A/E who determined the new design quantities.

IV. ENERGY AND COST SAVINGS

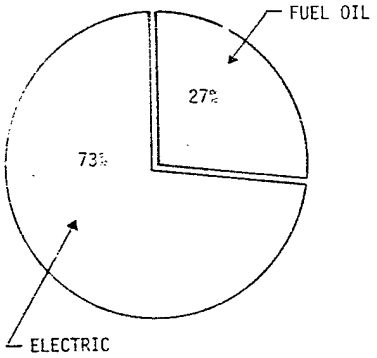
4.1 POST IMPLEMENTATION CONSUMPTION LEVELS

After implementation of the projects recommended in Increments A, B and F, Building 2 annual electrical consumption will be reduced by 169,721 MBTU (Equivalent) and annual fuel oil consumption by 109,267 MBTU. Allocation of these reductions is as follows:

Project	Electrical Reduction MBTU	#6 Fuel Oil Reduction MBTU
Enthalpy Economizer	6498	-
EMCS	43,516	28,576
Lighting System Mods.	10,209	-
Heat Transfer Loop Mods.	246	7,471
Air Flow Reduction/Rebalancing	110,291	65,717
Seasonal Reset of Thermostats	-1,039	7,503
	169,721	109,267

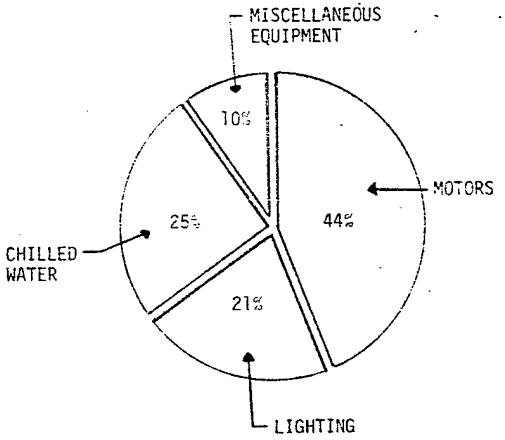
In addition, completion of the in-house delamping program and full operation without secondary chilled water pumps should further reduce annual electrical consumption levels by 15,200 MBTU (equivalent). Refer to Figures 4-1 and 4-2 for "pie charts" contrasting annual energy consumption before and after implementation of the recommended scope of ECMs.

NOTE: ALL PERCENTAGES ROUNDED



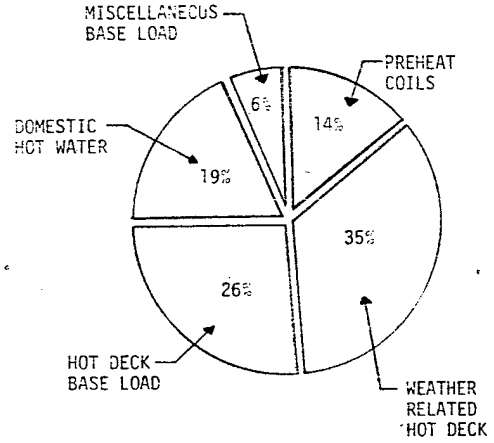
TOTAL ENERGY

TOTAL = 1,020,449 MBTU



ELECTRIC CONSUMPTION

TOTAL = 743,329 MBTU

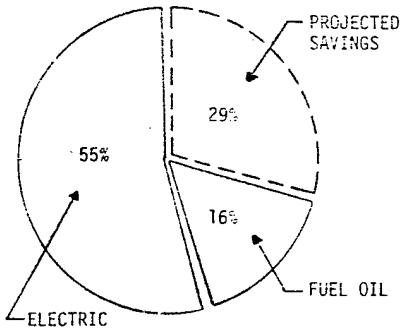


#6 FUEL OIL CONSUMPTION

TOTAL = 277,120 MBTU

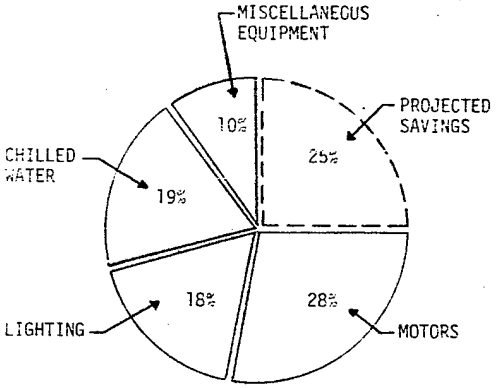
FIGURE 4-1 BUILDING 2 ANNUAL CONSUMPTION BREAKDOWN - FY'82

NOTE: ALL PERCENTAGES ROUNDED



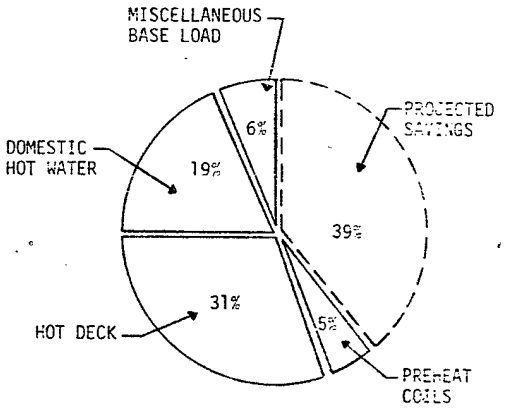
TOTAL ENERGY

TOTAL = 1,020,449 MBTU
PROJECTED USE = 726,261 MBTU
SAVINGS = 294,188 MBTU



PROJECTED ELECTRIC CONSUMPTION

TOTAL = 743,329 MBTU
PROJECTED USE = 558,408 MBTU
SAVINGS = 184,921 MBTU



PROJECTED #6 FUEL OIL CONSUMPTION

TOTAL = 277,120 MBTU
PROJECTED USE = 167,853 MBTU
SAVINGS = 109,267

FIGURE 4-2 BUILDING 2 ANNUAL CONSUMPTION ESTIMATE - FY'88 (USES FY'82 AS COMPARATIVE BASE)

4.2 PROJECTED ENERGY COSTS

When data from the previous section is summarized and subtracted from FY'82 consumption data of Section 2.2, Building 2 annual electrical consumption is 558,408 MBTU (equivalent) and annual #6 fuel oil consumption is 167,853 MBTU. In that full benefit of all recommended projects will not be available until FY'88, projected FY'88 costs of $5.28 per MBTU electrical and $8.60 per MBTU fuel oil must be applied against annual consumption projections in order to determine probable operating costs. The following results are obtained:

FY'88 Projected Building 2 Electrical Costs	$2,948,394
FY'88 Projected Building 2 #6 Fuel Oil Costs	$1,443,536
	$4,391,930

V. INCREMENT F SUMMARY

5.1 IN-HOUSE ENERGY CONSERVATION MODIFICATIONS

The following energy conservation modifications have been accomplished by WRAMC personnel since Building 2 was totally occupied in late 1978.

1. A major delamping and relamping program was begun in September 1979 and is nearing completion at the present time.

2. Air handling unit winter mode control sequence modifications were initiated in 1981.

3. Building 2 secondary chilled water pumps were equipped with valved bypass lines during the summer of 1982 and the pumps are now shutdown.

5.2 INCREMENT F MODIFICATIONS

As discussed during the Interim Submittal review conference, a few of the projects considered under Increment F should be tried on a "pilot project" basis on one or two air handling systems before any recommendation is made to extend such projects to all air handling systems. The projects recommended for such a trial implementation are indicated in Table 5-1 along with other projects evaluated for Increment F.

5.3 PLANNED FACILITIES CHANGES

The installation master plan does not include sufficiently detailed information about any planned facilities changes for Building 2 to allow energy use estimates to be developed and accounted for in the EEAP.

	DESCRIPTION	SIR	CURRENT CONSTRUCTION COST			IMPLEMENTATION MAN-HOURS BY TRADE					ANNUAL ENERGY SAVINGS					
											ELECTRICAL		#6 FUEL OIL		TOTAL	
			LABOR	MATERIAL	TOTAL	FITTER	APPRENTICE	ELECTRICIAN	PROGRAMMER	ENGINEER	MBTU	$	MBTU	$	MBTU	$
1.	ENTHALPY ECONOMIZER MODIFICATIONS	5.11	13,969	32,057	46,026	210	-	74	80	-	6,498	28,656	-	-	6,498	28,656
2.	HEAT TRANSFER LOOP MODIFICATIONS	2.33	27,387	172,120	199,507	420	280	140	-	-	246	1,085	7,471	46,544	7,717	47,629
3.	SEASONAL RESET OF THERMOSTATS	1.87	23,177	0	23,177	-	864	-	-	160	-1,039	-4,582	7,503	46,744	6,464	42,162
			64,533	204,177	268,710	630	1,144	214	80	160	5,705	25,159	14,974	93,288	20,679	118,447
4.	CLEAN HOT DECK AND COLD DECK COILS		Coils not accessible for cleaning. Refer to page 195 for details.*													
5.	RELOCATE AHU STEAM HUMIDIFIERS		Humidity requirements and AHU configuration do not allow for cost effective relocation. Refer to page 201 for details.*													
6.	CHANGE ELECTRICAL MOTORS TO HIGH EFFICIENCY TYPE		High labor costs resulting from interfloor congestion do not allow for cost effective changeout. Refer to Section 10.4 of the Main Report for details.													

NOTE: 1. All cost information calculated for current year.

2. Measures 1 and 2 recommended for implementation on a pilot basis before extension to all applicable units/systems.

3. Heat transfer loop modifications project includes cleaning of transfer coils and preheat coils.

*Refer to Main Report Volume.

TABLE 5-1 INCREMENT F SUMMARY

5.4 INCREMENTS A,B,F,G - PROJECT SUMMARY

The projects considered as a result of required evaluations for Increments A, B, F and G are summarized in Table 5-2.

VI. ENERGY PLAN

6.1 PROJECT MATRIX

The scope of Energy Conservation Investment Program (ECIP) projects and Increment F projects developed for Building 2 is summarized in Table 6-1, Page 19. It should be pointed out that continuation of the in-house delamping program and full operation without secondary chilled water pumps will further reduce FY'83 energy consumption (as compared to FY'82) by as much as 15,200 MBTU electric (or 11,003 BTU/SQ FT/YR) before accounting for the impact of the projects in Table 6-1.

The recommended scope of retrofit projects will enable Building 2 to achieve a 27% reduction in annual energy consumption when compared to base year FY'79. In order to achieve this reduction and improve existing environmental conditions, the following order is recommended for implementation.

1. Air flow reduction and air side rebalancing.

2. Energy Monitoring and Control System.

3. Increment F pilot projects.

	DESCRIPTION	EEAP INCREMENT	SIR	CURRENT CONSTRUCTION COST	ANNUAL ENERGY SAVINGS ELECTRICAL MBTU	ELECTRICAL $	#6 FUEL OIL MBTU	#6 FUEL OIL $	BASIS OF EVALUATION
1.	ENTHALPY ECONOMIZER MODIFICATIONS	F	5.11	$ 46,026	6,498	28,656	-	-	ALL APPLICABLE SYSTEMS
2.	OPERATING ROOM SUPPLY AIR REDUCTION	A	3.09	18,696	2,198	9,693	363	2,261	SA8SE1
3.	INTERFLOOR INCANDESCENT LIGHTING FIXTURE CHANGEOUT	A	2.83	100	5.2	15.29	-	-	TYPICAL FIXTURE
4.	ENERGY MONITORING AND CONTROL SYSTEM	B	2.71	1,467,631	43,516	133,821	28,576	178,028	ENERGY RELATED POINTS ONLY
5.	HEAT TRANSFER LOOP MODIFICATIONS	F	2.33	199,507	246	1,085	7,471	46,544	ALL APPLICABLE SYSTEMS
6.	SEASONAL RESET OF THERMOSTATS	F	1.87	23,177	-1,039	-4,582	7,503	46,744	
7.	REDUCE SUPPLY AIR QUANTITY	A	1.59	26,307	1,458	6,430	346	2,156	SA5NW3
8.	PHOTOCELL DIMMING OF INTERSECTING BRIDGE CORRIDOR FIXTURES	A	1.39	1,483	42	185	-	-	TYPICAL INTERSECTING BRIDGE CORRIDOR
9.	REDUCE SUPPLY AIR QUANTITY	A	1.26	29,053	1,315	5,799	283	1,763	SA5NW2
10.	VARIABLE AIR VOLUME CONVERSION	A	1.19	72,132	1,427	6,293	179	1,117	SA5NW3
11.	REDUCTION OF GLASS AREA	A→G	0.77	577,119	2,542	7,471	2,902	18,090	34,821 SQUARE FEET OF PANELS
12.	OPERATING ROOM - UNOCCUPIED CYCLE SUPPLY AIR REDUCTION	A	0.67	61,605	1,314	3,062	370	2,305	SA8SE1
13.	RETURN AIR ADDITION	A	0.65	140,507	236	1,041	924	5,757	SA5NE2
14.	LOW VOLTAGE SWITCHING OF CORRIDOR LIGHTS	A→G	0.61	1,312	31	72	-	-	TYPICAL 10 FIXTURE CORRIDOR
15.	ADDITIONAL INSULATED PANELS	A	-	388,872	94	275	472	2,945	23,568 SQUARE FEET OF PANELS
16.	CLEAN HOT DECK AND COLD DECK COILS	F		Coils not accessible for cleaning. Refer to page 195 for details.*					
17.	RELOCATE AHU STEAM HUMIDIFIERS	F		Humidity requirements and AHU configuration do not allow for cost effective relocation. Refer to page 201 for details.*					
18.	CHANGE ELECTRICAL MOTORS TO HIGH EFFICIENCY TYPE	F		High labor costs resulting from interfloor congestion do not allow for cost effective changeout. Refer to Section 10.4 of the Main Report for details.					

*Refer to Main Report Volume.

TABLE 5-2 INCREMENTS A, B, F AND G SUMMARY

	DESCRIPTION	EEAP INCREMENT	SIR	CURRENT ADJUSTED CONSTRUCTION COST	ANNUAL ELECTRICAL REDUCTION MBTU (EQUIV)	BTU/SQ FT/YR	% FY'79	ANNUAL #6 FUEL OIL REDUCTION MBTU	BTU/SQ FT/YR	% FY'79	CONSTRUCTION SCHEDULE START	DURATION (MONTHS)
MCA TYPE PROJECTS	1. ENERGY MONITORING AND CONTROL SYSTEM	B	2.71	$1,467,631	43,516	31,500	5.6%	28,576	20,686	11.4%	FEB '86	18
	2. LIGHTING SYSTEM MODIFICATIONS	A	2.69	206,404	10,209	7,390	1.3%	-	-	-	FEB '86	6
	3. AIR FLOW REDUCTION AND AIR SIDE REBALANCING	A	2.31	1,922,526	110,291	79,838	14.2%	65,717	47,571	26.2%	FEB '86	12
				3,596,561	164,016	118,728	21.1%	94,293	68,257	37.6%		
OMA TYPE PROJECTS	1. ENTHALPY ECONOMIZER MODIFICATIONS	F	5.11	46,026	6,498	4,704	0.8%	-	-	-	OCT '87	6
	2. HEAT TRANSFER LOOP MODIFICATIONS	F	2.33	199,507	246	178	-	7,471	5,408	3.0%	FEB '86	12
	3. SEASONAL RESET OF THERMOSTATS	F	1.87	23,177	-1,039	-752	-0.1%	7,503	5,431	3.0%	REQUIRED EVERY SIX (6) MONTHS	
				268,710	5,705	4,130	0.7%	14,974	10,839	6.0%		
				3,865,271	169,721	122,858	21.8%	109,267	79,096	43.6%		

TABLE 6-1 ENERGY PLAN MATRIX

4. Lighting system modifications.

5. Seasonal reset of thermostats.

6.2 REVISED ANNUAL ENERGY CONSUMPTION

The data in Table 6-1 gives the annual energy consumption reductions for each of the recommended projects.

After implementation of the remaining elements of the in-house energy conservation program and the recommended ECIP and Increment F projects, Building 2 annual energy consumption should be as follows. In that construction on all projects is scheduled to begin on 1 February 1986, with the projects having the larger impact on annual energy consumption lasting from 12 to 18 months, these annual consumption projections would not become totally effective until FY'88.

ELECTRICITY	47,822,068 KWH
	558,408 MBTU
	404,221 BTU/SQ FT/YR
	28% REDUCTION OVER FY'79
#6 FUEL OIL	1,181,192 GAL
	167,853 MBTU
	121,505 BTU/SQ FT/YR
	33% REDUCTION OVER FY'79
TOTAL ENERGY	726,261 MBTU
	525,726 BTU/SQ FT/YR
	29% REDUCTION OVER FY'79